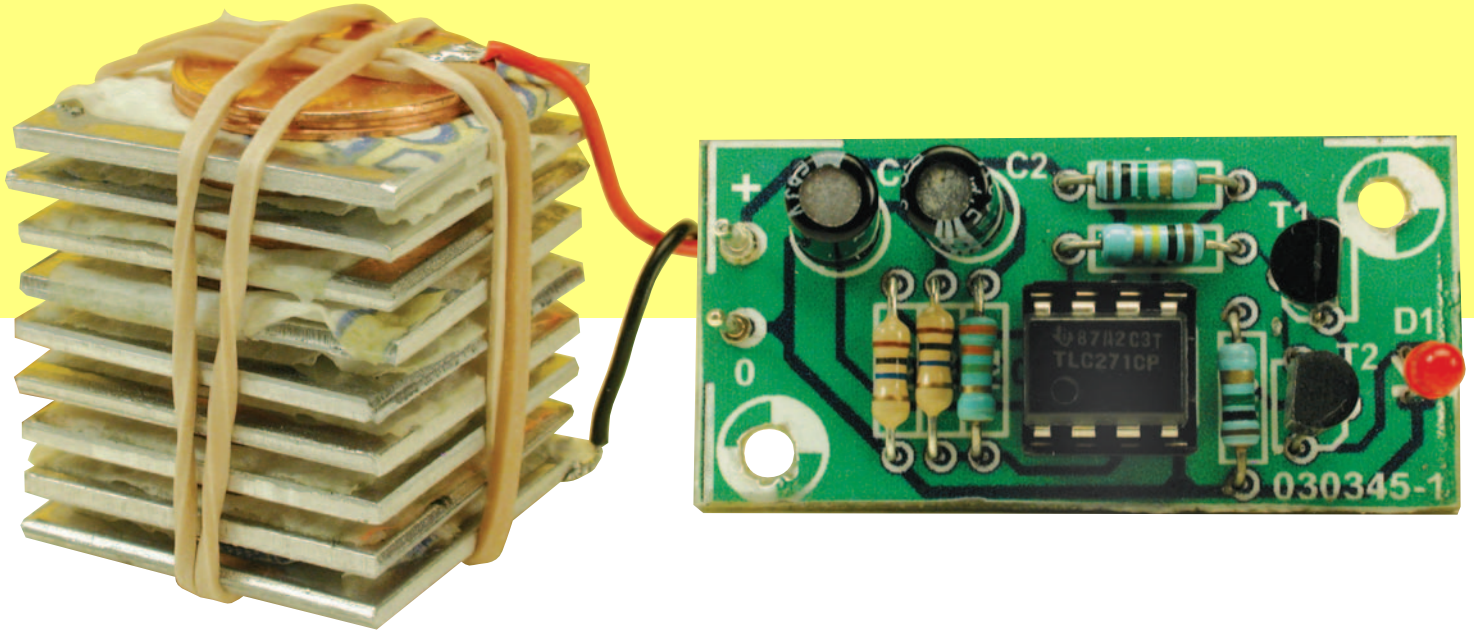




Prof. Dr. Martin Ohsmann

Low-Power LED Flash powered by lemon juice

This circuit will need just a few micro-amps to make an LED flash. The energy comes from a home made 'vegetarian' battery.

We have to admit that the circuit shown in **Figure 1** appears a bit over the top for an on/off indicator, as the same functionality could have been achieved from a classic combination of an LED and a series resistor. However, the circuit is unbeaten we feel in that it shows how a visual on/off indication may be realised in battery-powered equipment, while using a minimum of energy.

It is of course impossible to make an LED light continuously with very little current. The solution is to make it flash briefly. The requirement, then, is for a low-energy oscillator capable of

creating an extremely low duty factor (on/off ratio). A large time constant is realised by capacitor C1 in conjunction with charging resistor R1. Micropower opamp IC1 acts as an inverting comparator, monitoring the voltage on C1 and comparing it with a threshold level defined by resistors R2 and R3. Once capacitor C1 contains sufficient charge, it has to be discharged again. The energy stored in the capacitor is of course not wasted but put to good use — in this case powering the LED.

In order to create a relatively intense current peak through the LED, the

capacitor is discharged through a 'thyristor tetrode' formed by T1 and T2. This composite device is triggered by the comparator via R5. Because the thyristor tetrode does not consume current as C1 is being charged and the Micropower opamp itself is an extremely energy-wise component, the total current consumption remains extremely low — just 15 μA at 12 V. The circuit will function from a supply voltage as low as 3.5 V, although the LED in that case will not light brightly anymore. On a positive note, the current consumption is then reduced to just 4 μA !

COMPONENTS LIST

Resistors:

R1, R6 = 1M Ω
R2 = 3M Ω 3
R3, R4 = 9M Ω 1
R5 = 100k Ω

Capacitors:

C1, C2 = 1mF 16V (see text)

Semiconductors:

D1 = LED, red, low current
IC1 = TS271C (see text)
T1 = BC557C
T2 = BC547C

Miscellaneous:

K1 = 2 solder pins

2 solder tags

9 copper or coppered discs (e.g. coins, see text)

9 aluminium discs (see text)

Absorbing kitchenpaper (see text)

1 lemon (or pure lemon juice, see text)

1 rubber ring

PCB, available from The PCB Shop

Construction

The construction on the printed circuit board shown in **Figure 2** is not critical in any respect. Capacitor C1 must be a foil-dielectric type (for example, Siemens MKT). C2, too, should exhibit a low leakage current because otherwise the current consumption will be far higher than desired. The LED should be a 'high-intensity' or a 'low-power' type.

The introductory photograph shows an initial attempt at construction using Vero board.

The circuit employs a micropower operational amplifier type TS271C from ST (formerly SGS-Thomson). This is **not** a direct replacement form the TLC271, although the latter device may also be used in this circuit if you remember to link pin 7 to 8 in order to preserve the low-bias setting. Resistor R4 which defines the bias current with the TS271 is then omitted.

Add some lemon juice

The extremely low current consumption at reasonable supply voltages actually allows our little circuit to be powered from a home-made battery. The general idea is depicted in **Figure 3**.

The battery consists of a nine individual elements connected in series by stacking. Each element is made up from a (coppered) coin with a diameter of 10-15 mm, a separating sheet made from kitchen paper soaked in lemon juice, and a piece of aluminium foil. The components that constitute the 'veggie battery' are also visible in the introductory photograph.

Several experiments were carried out and the following procedure was found to give best results: fold the aluminium foil eight times and use the circumference of the coin to cut out eight round packets in one go. Next, cut nine

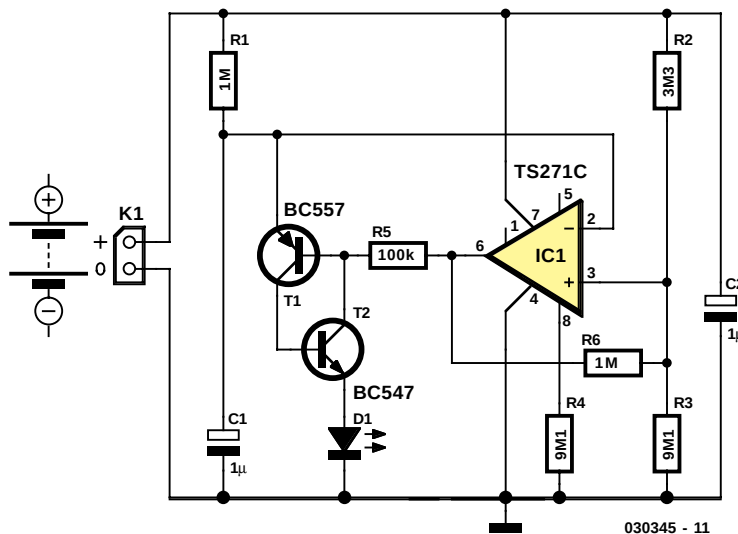


Figure 1. Circuit diagram of the energy-wise LED flasher employing the TS271C micropower opamp.

square pieces of kitchen paper, the edges should be slightly longer than the diameter of the coin. This is necessary to prevent a short circuit between copper and aluminium. Then saturate the paper with lemon juice. Freshly pressed juice will work better than juice from a bottle!

The lower part of the battery assembly is formed by a slightly larger piece of aluminium foil — this will act as the negative terminal. On it lies a paper disc. Then stack on a coin, an aluminium disc, a paper disc and so on, right up to the top coin that acts as the positive terminal. If you are satisfied with your creation, the presence of a voltage may be proved with the aid of a high-impedance digital voltmeter. The battery terminal voltage should be between 3 V and 4 V. Connect the battery to the circuit and you'll be able to watch the LED flash for quite a while getting its energy from... lemon juice!

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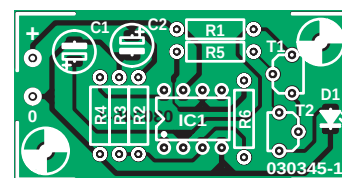


Figure 2. A PCB to try it all out.

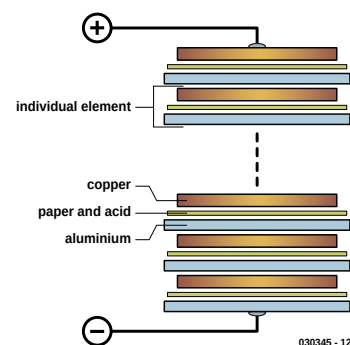


Figure 3. Schematic representation of the battery.